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Br. May 12, 1948.

601,724 COMPLETE SPECIFICATION

SHEET 1

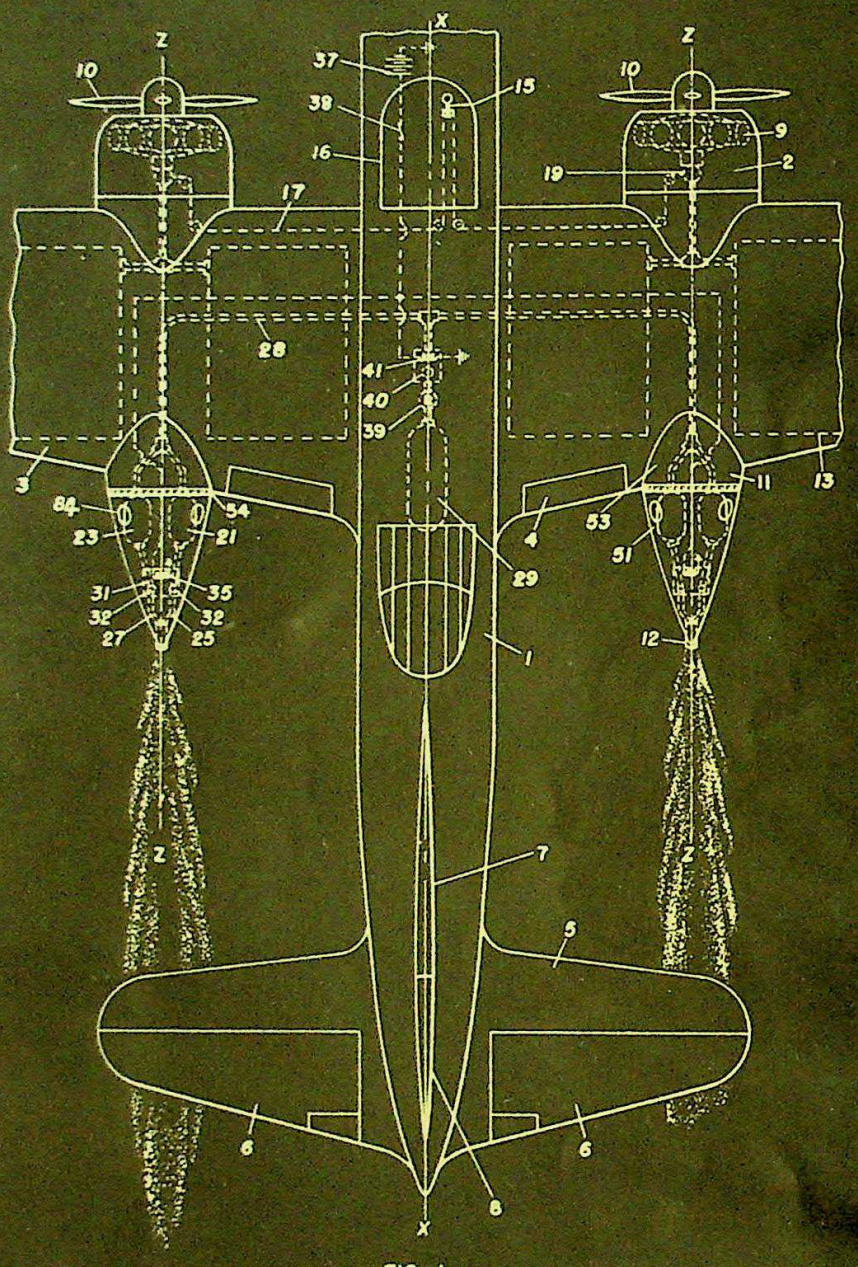

FIG. 1

[This Drawing is a reproduction of the Original on a reduced scale.]

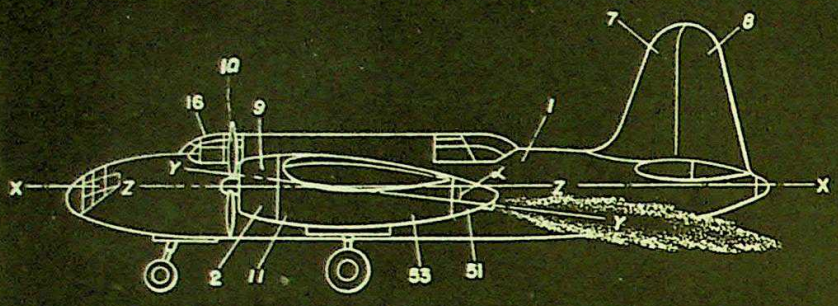

FIG. 2

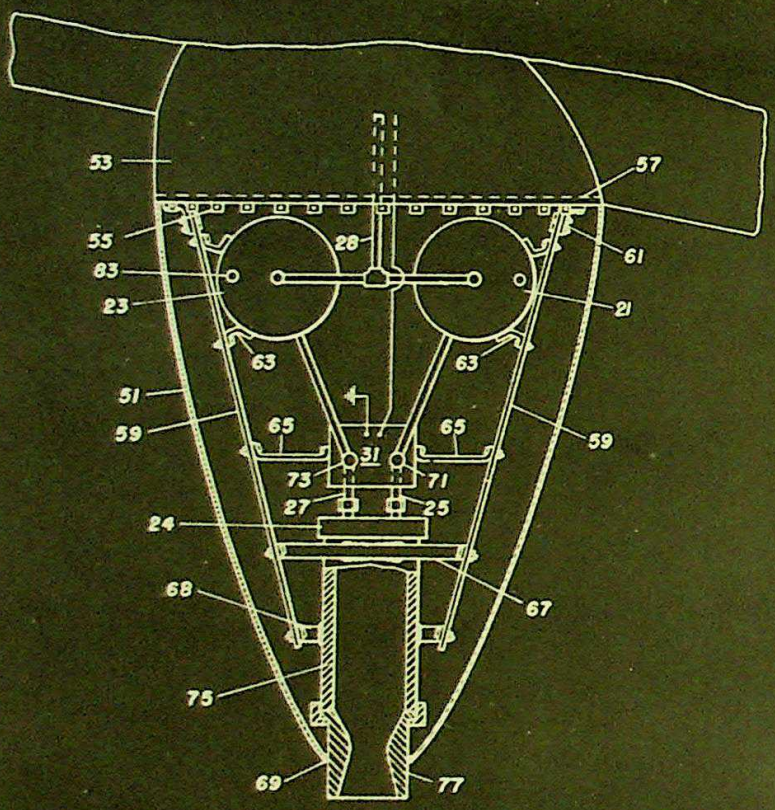

FIG. 3

H.M.S.O.(Ty. P.)

PATENT SPECIFICATION 601,724

Convention Date (United States of America): May 29, 1943.
Application Date (in United Kingdom): May 23, 1944. No. 9979/44.
Complete Specification Accepted: May 12, 1948.
(Under Section 6 (1) (a) of the Patents &c. (Emergency) Act, 1939, the proviso to Section 91 (4) of the Patents and Designs Acts, 1907 to 1946, became operative on Nov. 26, 1946).

Index at acceptance:—Classes 4, A3a(1a:1c:2b:2c), G5, H1a; 51(i), A1b1; and 110(ii), J2b.

COMPLETE SPECIFICATION

Improvements in or relating to Propelling Means for Aircraft

We, AEROJET ENGINEERING CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 285 West Colorado Street, City of Pasadena, State of California, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention pertains to jet, or rocket, propulsion and pertains more particularly to the application of jet, or rocket, propulsion systems to heavier-than-air craft to provide thrust auxiliary to that normally provided by the primary source of power.

In accordance with one form of the present invention, the improved aircraft includes a propeller supported thereon, throttling means for varying the rotation of the propeller about its thrust axis, a streamlined nacelle behind said propeller having an opening adjacent the rear end thereof, a jet motor mounted within said nacelle with its nozzle in line with said opening, said jet motor and associated propeller having thrust axis substantially coincident in plan view, and control means separate from said throttling means for initiating the production of combustion in said jet motor.

In another form of the present invention, the improved aircraft includes a number of propellers supported thereon, means for controlling the rotation of said propellers about their respective thrust axes, a hollow streamlined nacelle behind each such propeller said nacelle having an opening adjacent the rear end thereof, a jet motor mounted within said nacelle with its nozzle in line with said opening, each said jet motor and associated propeller having thrust axes substantially coincident in plan view, and means for initiating the production of combustion of propellants in said jet motor independently of said propeller rotation.

According to a further form of the present invention the improved aircraft comprises a wing surface for supporting the craft in flight, a number of propellers supported from the wing surface, means for controlling the rotation of said propellers about their respective thrust axes, a nacelle behind each such propeller said nacelle having an opening adjacent the rear end thereof, a jet motor mounted within the nacelle with its nozzle in line with said opening, and means for producing combustion in said jet motor independently of the control of the propeller rotation.

According to a still further form the present invention comprises an aircraft having a wing surface for supporting the craft in flight, a number of propellers supported from the wing surface, a streamlined member associated with each propeller having an opening adjacent the rear end thereof, first control means for varying the thrust produced by said propellers along their respective thrust axes, a number of jet motors mounted each in one of said streamlined members with its nozzle in line with said opening with its thrust axis substantially intersecting the transverse axis through the centre of gravity of the aircraft, said propellers and jet motors being symmetrically arranged with respect to said longitudinal axis and second control means for simultaneously initiating combustion in all said jet motors. For simplicity, our invention will be described in conjunction with the use of a pair of spontaneously combustible propellants, though it is also applicable to systems utilizing propellants which are not spontaneously combustible.

In order to avoid excessive aerodynamic disturbances to the flight of the aircraft when the jet motor is in opera-

tion, the thrust axis of the jet motor is directed along a line displaced from any control surfaces which may be incorporated in the aircraft, and any such control surfaces that are seriously exposed to the heating effects of the exhaust gases are coated with a heat resistant material to prevent injury to such surfaces by the intense heat of gas expelled from the jet motor.

In order to produce additional lift, as well as longitudinal thrust, we prefer to mount the jet motor with its thrust axis directed at a small angle below the longitudinal axis of the airplane.

The principal object of our invention is to provide means for producing auxiliary thrust in an airplane with a minimum disturbance to the usual aerodynamic and flight control characteristics of the airplane.

Another object is to provide a simple means for the initiation of combustion of a number of jet motors installed on an aircraft.

Another object is to provide an installation of one or more jet motors on an aircraft, which may be readily operated during flight with a minimum effort of the pilot.

Still another object is to provide an efficient system of jet propulsion for assisted take off purposes.

The foregoing and other objects and features of advantages of our invention will be understood from the following description taken in conjunction with the accompanying drawings, in which:—

Fig. 1 is a plan view, partly schematic, of part of an aircraft incorporating our invention;

Fig. 2 is a side elevation of the aircraft partly shown in Fig. 1; and

Fig. 3 is a diagram partly in section of a jet motor unit installed in a nacelle.

The airplane illustrated in the drawings has a fuselage 1 to which there is secured a front or main wing surface 3 having associated ailerons 4, a tail wing or control surface 5 having the usual elevators 6, and a fin 7 with associated rudder 8. Two propellers 10 and two jet motors 12 are located on the front wing 3 and are symmetrically disposed with respect to the longitudinal axis X-X of the airplane.

Means are provided for independently controlling the production of thrust by the propellers and by the jet motors.

Smooth hollow, and preferably streamlined, members formed by cowlings 2 and nacelles 11 are supported from the main wing in symmetrical positions on opposite sides of the fuselage. Said members preferably extend from a point in front of the leading edge of the main wing to a point behind the trailing edge thereof.

Within the cowlings 2 in front of the leading edge of the main wing, there are installed main power plants 9 in the form of radial internal combustion engines. The propellers 10 are mounted on the shafts of these engines and in front of the cowlings.

Nozzles of the jet motor 12 project through apertures adjacent the aft end of the corresponding nacelles. The main portions of such jet motors are preferably mounted within the corresponding nacelles, so that they increase the drag on the aircraft by a minimum and so that when installed in a military plane the jet motor will be barely noticeable.

Fuel for the main power plants is contained within gasoline tanks 13 mounted within the main wing 3. The rate of flow of such gasoline to the propeller engines 9 and hence the primary thrust produced by them is readily controlled remotely by means of a throttle lever 15 in a control compartment, such as a cockpit 16. As here illustrated the throttle lever communicates by means of cables 17 with carburetors 19, or other gasoline flow control elements, connected in the lines between said gasoline tanks and said engines. The main power plants are adapted to produce thrust for relatively long times and are normally used full time during take off and during flight.

Pairs of spontaneously combustible propellants, one of which is a liquid fuel and the other of which is a liquid oxidizer, are contained in corresponding cylindrical tanks 21 and 23 installed in each nacelle. The propellant tanks communicate with separate orifices of an injector at one end of the jet motor through dispensing conduits 25 and 27. An inert gas is contained within an auxiliary tank 29 mounted in the fuselage. This tank is connected to the propellant tanks of both jet motors through suitable pressure lines 28. Force on the liquid propellants provided by such high pressure gas tends to urge said propellants through said conduits 25 and 27 into the combustion chamber of each jet motor. These conduits include corresponding valves 71 and 73 for controlling the flow of propellants into the combustion chamber.

The valves for each jet motor are incorporated in corresponding valve units 31 which are remotely and simultaneously controllable from the control compartment. In the preferred form of our invention, the valve units 31 associated with jet motors located on opposite

sides of the fuselage are connected to a single auxiliary control member in the cockpit so that the operation of such motors may be readily effected simultaneously with each other but independently of the control of the propellers 9.

The valve units 31 here illustrated are of the electromagnetic type. Each valve unit has means including a field coil 35 for opening and closing the valves. The valves are normally closed when no current flows in the field coil. In order to provide for simultaneous operation of the two jet motors, the two field coils 35 of the two valve units 31 are connected in parallel with each other, and in series with an electric power source such as a battery 37 and a switch 38 located in the cockpit.

If a pressure regulator 39 is included in conduit 28, an auxiliary electromagnetic valve 40 is preferably included in the conduit between the regulator and the propellant tanks of the two motors. The field coil 41 of this valve is also connected in parallel with the aforementioned field coils 35 so that this valve 41 may be actuated simultaneously with the propellant control valves 32 to avoid possible gradual increase in pressure on the low pressure side of the valve.

In Fig. 3 we have shown diagrammatically a simple means for mounting a jet motor and auxiliary parts in a nacelle. To facilitate installation, the tail cone 51 of the nacelle is arranged to be readily removed from the forward portion 53 of the nacelle. Thus, for example, said tail cone may be secured to said forward portion by means of bolts 54 screwed into threaded brackets 55 mounted circumferentially on the aft side of a fire wall 57 at the aft end of said forward portion.

A frame including two side supports 59-59 are secured to said fire wall in any convenient manner such as by bolting to brackets 61 on the fire wall. The fuel tank 21 and oxidizer tank 23 are supported from said side supports by means of suitable angle brackets 63.

The electromagnetic valve unit 31 is supported from said side supports by means of cross brace 65 intermediate the ends of said supports. The jet motor itself is mounted at the aft end of said supports by means of cross braces 67 and 68 which are welded to the external wall of the jet motor and which are bolted to the ends of the side supports. The entire assembly converges toward the rear so as to fit readily within the tail cone. The jet motor projects slightly through the aperture 69 in the tail cone adjacent the aft end thereof. A suitable conduit 28 is provided for connecting the source 29 of high pressure gas to the top of the propellant tanks 21 and 23. The dispensing conduits 25 and 27 connect the bottom of said tanks to corresponding injection orifices of the jet motor. Individual valves 71 and 73 of the electromagnetic valve unit are included in corresponding dispensing conduits 25 and 27 to control the flow of propellants into the jet motor. At the top of the propellant tanks are removable plugs 83 through which the tanks may be filled when desired. Openings 84, (shown in Figure 1) in the nacelle cone opposite the plugs facilitate filling.

To operate the jet motors the control switch 39 is closed. The propellant control valves 32 and the pressure line control valves 40 thereupon open, thereby permitting the fuel and oxidizer to be injected as separate streams into the combustion chamber 75 of each jet motor. The streams of propellants impinge, vaporize and mix, and burn spontaneously. The heated gases produced during combustion are expelled through the nozzle 77 in an aft direction from the jet motor under the influence of the energy of combustion.

Applied to assisted take-off, operation of the main power plant is first initiated in the normal manner and the take-off started. The jet motors are turned on when additional thrust is desired during the take-off run. During flight the jet motors may be simply operated for any time interval desired by proper manipulation of the switch 38.

When applied to assisted take-off sufficient supplies of propellants are provided so that if the airplane takes off at a lower take-off speed than that corresponding to the actual gross weight including load, the jet motors will continue to operate after the airplane leaves the ground and until a flying speed is attained corresponding to the thrust produced by the main power plant alone. Thereafter the thrust from the main power plant serves to sustain the airplane in flight.

In practice it is observed that some combustion may occur externally to the jet motor and regardless of whether such external combustion occurs, the gases exhausted from the jet motor are at a high temperature and travel at a high speed. The heat radiated from such exhaust gases is liable to overheat neighbouring parts of the airplane. Because of the high temperature of the expelled gases and their high speed they are preferably directed along a line displaced from any control or supporting surfaces

such as the stabilizer surface 5 or elevators 6 thus reducing to a minimum any aerodynamic interference with the normal operation of such surfaces.

If the exhaust gases were not directed along a line displaced from the tail surface, turbulence created in the neighborhood of such surface could produce forces thereon which would disturb the smooth flight of the aircraft. Furthermore the hot expelled gases could damage the skin of such surfaces.

For this reason we prefer to install jet motors on airplanes in which the supporting and controlling surfaces are mounted on the airplane at positions displaced from the thrust axes of the propellers. When jet motors are installed on such aircraft the thrust axes of the jet motors may be made substantially coincident with the thrust axis Z-Z of the corresponding propeller without overheating such surfaces.

In the event that the thrust axis Y-Y of a jet motor must be inclined somewhat from the thrust axis Z-Z of the associated propeller in order to avoid damage or interference with one of the supporting or controlled surfaces, the jet motor should preferably be installed at such position that its thrust axis substantially intersects the lateral axis of the airplane. By substantial intersection of such axes we mean that the distance between the thrust axis and the lateral axis is no more than a small fraction, say about one fifth, of the radius of gyration of the airplane about the lateral axis.

As a further aid in minimizing aerodynamic disturbances to the aircraft, the supporting or control surfaces which are exposed to the heating effects of the exhaust gases are painted with a fire resistant material over which a finish coat of highly heat reflective material is placed. Such fire resistant coating may for example be composed of fire resistant enamel such as zinc-chromate bound in alkyd resins in a solvent such as toluene. Such heat reflective coating may for example comprise an aluminized varnish. In the present instance the lower surface of the tail is so treated.

In the case of the airplane shown the tail surface is above the thrust axes Z-Z of the propellers and the thrust axes of the jet motors are directed downward in the aft direction at an angle (α) of about 7° so that they extend along a line passing beneath the tail and several feet therefrom. This angle is so selected that the external flame does not strike the ground when the jet unit is utilized for assisted take-off. If it did strike the ground the intense heat could damage the composition, such as asphalt, forming the floor of the take-off field.

A further advantage in inclining the thrust axis downward toward the rear lies in the fact that an upward component of thrust may be produced simultaneously with a forward component of thrust. Such upward component reduces the drag due to the rolling friction of the airplane on the ground and also increases the lift. These two effects combine to reduce the distance required to take-off with normal load and to increase the pay load which may be carried when normal take-off distance may be used. While such reduction in take-off distance is ordinarily small as long as the jet motor thrust is smaller than the propeller thrust, even small gains in reducing take-off distance are sometimes of value.

On the other hand when applied to assisted take-off using normal take-off distances the increase in lift serves to substantially increase the pay load which can be carried over what such pay load would be if the jet thrust were applied along a line parallel to the propeller thrust. In general if the auxiliary thrust provided by a jet motor is T lbs., with such jet motor set at an angle α in a vertical plane, the additional pay load which can be carried, due to such inclination, is about T sin α, With T = 2,000 lbs. and = 7°, this represents extra pay load of about 250 lbs. more than could be lifted during take-off by installation of the jet motor with its thrust axis horizontal.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. An aircraft including a propeller supported thereon, throttling means for varying the rotation of said propeller about its thrust axis, a streamlined nacelle behind said propeller having an opening adjacent the rear end thereof, a jet motor mounted within said nacelle with its nozzle in line with said opening, said jet motor and associated propeller having thrust axes substantially coincident in plan view, and control means separate from said throttling means for initiating the production of combustion in said jet motor.

2. An aircraft including a number of propellers supported thereon, means for controlling the rotation of said propellers about their respective thrust axes, a hollow streamlined nacelle behind each

such propeller, said nacelle having an opening adjacent the rear end thereof, a jet motor mounted within said nacelle with its nozzle in line with said opening, each said jet motor and associated propeller having thrust axes substantially coincident in plan view, and means for initiating the production of combustion of propellants in said jet motor independently of said propeller rotation.

3. An aircraft according to Claim 1 or 2, having a control compartment for said aircraft, control means in said compartment for controlling the rotation of the propeller or propellers about their respective thrust axes, and means in said control compartment for initiating combustion in said jet motor or motors independently of the control of propeller rotation.

4. An aircraft according to Claim 1, 2 or 3, having containers of combustible liquid propellants associated with each jet motor, and means for controlling the injection of said propellants into the combustion chamber of each jet motor independently of the control of the power plant or plants connected to the propeller or propellers.

5. An aircraft according to Claim 4, wherein said containers of combustible liquid propellants are located within a hollow streamlined member associated with each propeller.

6. An aircraft having a wing surface for supporting the craft in flight, a number of propellers supported from the wing surface, means for controlling the rotation of said propellers about their respective thrust axes, a nacelle behind each such propeller, said nacelle having an opening adjacent the rear end thereof, a jet motor mounted within the nacelle with its nozzle in line with said opening, and means for producing combustion in said jet motor independently of the control of propeller rotation.

7. An aircraft according to Claims 3 or 6, having control means for simultaneously initiating combustion in said jet motors.

8. An aircraft having a wing surface for supporting the craft in flight, a number of propellers supported from the wing surface, a streamlined member associated with each propeller having an opening adjacent the rear end thereof, first control means for varying the thrust produced by said propellers along their respective thrust axes, a number of jet motors mounted each in one of said streamlined members with its nozzle in line with said opening with its thrust axis substantially intersecting the transverse axis through the center of gravity of the aircraft, said propellers and jet motors being symmetrically arranged with respect to said longitudinal axis, and second control means for simultaneously initiating combustion in all said jet motors.

9. An aircraft according to any of Claims 2 to 8, having a pair of containers of combustible propellants associated with each said jet motor, dispensing conduits connecting said containers with corresponding injection orifices in the corresponding jet motor, an electromagnetic valve associated with each motor adapted to control the flow of such propellants into the motors, and a common control switch and a battery connected to said electromagnetic valves whereby said valves may be opened and closed simultaneously.

10. An aircraft according to Claim 9, wherein said pair of containers of combustible propellants are located in each nacelle.

11. An aircraft according to any of Claims 2 to 10, having a front wing surface and a tail surface for supporting the craft in flight, said tail surface being displaced vertically from the longitudinal axis, a number of propellers mounted on the wing surface, a number of jet motors mounted with their thrust axes substantially intersecting the transverse axis through the center of gravity of the aircraft and diverging in a vertical plane from the longitudinal axis on the opposite side thereof from the tail surface, and means for initiating combustion in said jet motors.

12. An aircraft according to any of the preceding claims, wherein the thrust axis of each of said jet motors extends toward the rear and downward at a small angle from the longitudinal axis of the aircraft whereby a thrust may be produced in a forward and upward direction during take-off.

13. An aircraft according to any of the preceding claims, wherein the thrust axis of each jet motor is directed rearwardly along a line displaced vertically from the tail surface on said aircraft, said tail surface having a heat resistant coating covering the parts thereof exposed to heat radiating from the exhaust gases expelled from said jet motor.

14. An aircraft according to any of Claims 4, 5, 9 or 10, including a common container adapted for holding gas at high pressure, means connecting said pressure container to each said propellant container and adapting to force such propellants through dispensing conduits into the jet motor or motors.

15. An aircraft, having its parts con-

structed and adapted to operate substantially as herein described with reference to the embodiments shown in Figures 1 to 3 inclusive of the accompanying drawings.

Dated the 23rd day of May, 1944

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Printed for His Majesty's Stationery Office by Charles Birchall & Sons, Ltd., Liverpool.—1948.
Code 39-219. Published at the Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies, price 1s. 0d. each (inland) 1s. 1d. (abroad) may be obtained.

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